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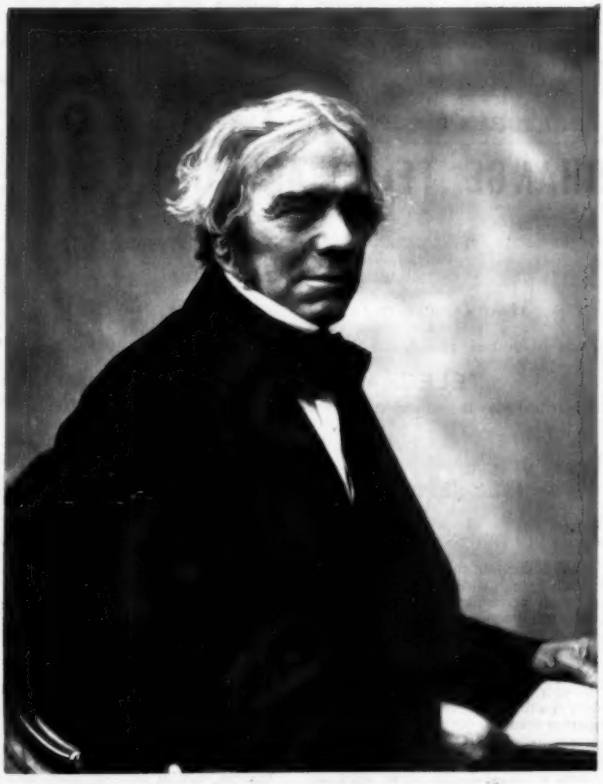


FROM A PHOTOGRAPH BY MR. E. J. MAYALL.

## MICHAEL FARADAY.

THE materials for a biographical sketch of Faraday are only too abundant. Dr. Bence Jones has told us the story of his life in two large volumes; Professor Tyndall has described "Faraday as a discoverer;" and Dr. J. H. Gladstone, his successor at the Royal Institution, has worked up his own reminiscences into a picture, equally vivid and fascinating, of the *man*.

In the beginning of the present century Sir Humphry Davy was dazzling the scientific world by a series of discoveries which for brilliancy and rapidity is almost without a parallel. His crowning achievement—the discovery of the alkaline metals—

was made before he was thirty. A few years later, however, he was to render a still greater service to science, though an indirect one, by giving Michael Faraday a place in which it was possible that he could become a philosopher.

Faraday was born at Newington Butts, on September 22, 1791. The third child of a journeyman blacksmith, his early education was, he tells us, very scanty, and when he was thirteen he was sent out to earn a little money as errand boy to Mr. George Riebau, a bookseller. After a year of this work his master took him as apprentice, and in 1812 he became a journeyman bookbinder. During the seven years of his apprenticeship he was far from confining his attention to the outsides of the books that passed through his hands, and, besides this, his master allowed him to attend evening lectures by Mr. Tatum, on Natural Philosophy. Towards the close he even went to hear Davy lecture at the Royal Institution, and became possessed of a desire to be engaged in scientific work, of however humble a kind.

A year as a journeyman under a new and much less kind master made this desire become a passion, and he resolved on a bold step. Writing out in full the notes he had taken of Sir Humphry Davy's lectures, he sent them to him and asked for scientific work. Davy answered kindly, but he had none to offer just then. A few months later, however, in March 1813, the situation of laboratory assistant at the Royal Institution became vacant, and Faraday was engaged at 25*s.* a week. Science gave her new votary a somewhat rough welcome, for almost the first work he had to do was to assist Davy in an examination of chloride of nitrogen—the most dangerously explosive substance known—until both master and man were too much damaged to care about continuing the experiments.

From this time up to 1820, the period of what Dr. Bence Jones has called Faraday's earlier scientific education was passed. Eighteen months were spent in a Continental tour with Davy, the rest at the Royal Institution. It was not till the end of that time that his career as a discoverer can fairly be said to have begun.

Oersted had discovered, in 1819, the action of an electric current on a suspended magnetic needle, and his discovery had been splendidly extended by Ampère, before Faraday, in 1821, took up the subject, and obtained the rotation of a wire in the voltaic circuit round a magnet, and of a magnet round the wire. His great electrical discoveries did not, however, take place till much later. In 1823 he succeeded in reducing chlorine to a liquid form, and soon all but six gases yielded to the combined influence of cold and pressure. For some years more his work was almost wholly chemical.

His great life-work now began, and it continued for a quarter of a century. Beginning his researches in electricity on August 29, 1831, on the third day of his experiments (September 24) he obtained "distinct conversion of magnetism into electricity," the production of an electric current by magnetising the iron core of a conducting helix. On the fourth day (October 1) he found that an electric current *induced* a momentary current in a closed circuit near it at the instant when contact was made or broken in the first circuit. The fifth day brought with it the discovery of the production of a current by moving a magnet in the neighbourhood of a wire. On the ninth day he made a copper disc turn round between the poles of a powerful magnet, and found that a current flowed from the centre to the edge, and on the tenth he produced the current by drawing a short piece of wire between the poles. In describing this experiment, he used a phrase which has become classical—"Lines of magnetic force." He now saw that the condition for the production of a current was simply that the conductor should *cut* across the lines of force.

Faraday next occupied himself, for some time, in showing by experiment that the effects which he had obtained with artificial magnets were also obtainable by aid of the magnetism of the earth, and in proving the identity of frictional and voltaic electricity. On February 8, 1832, he obtained, for the first time, the magneto-electric spark—an experiment which inspired Herbert Mayo with the following impromptu:—

> Around the magnet, Faraday
> Was sure that Volta's lightnings play:
> But how to draw them from the wire?
> He drew a lesson from the heart;
> 'Tis when we meet, 'tis when we part,
> Breaks forth the electric fire.

But we must hasten on to mention his next great discovery—the law of electro-chemical action—that the amount of chemical decomposition effected by an electric current is simply proportional to the quantity of electricity which passes. This research took place in 1833-4. Other results of it were the coining (by Whewell) of the words "electrolysis," "electrolyte," "ion," "electrode," &c., and the invention of the Voltameter as a means of measuring the strength of currents.

In so short an article as the present, it is impossible even to mention Faraday's numerous discoveries in electricity. The student must be referred to the published "Experimental Researches." "He will there find," says Clerk-Maxwell, "a strictly contemporary-historical account of some of the greatest electrical discoveries and investigations, carried on in an order and succession which could hardly have been improved if the results had been known from the first."

Faraday's researches on electrostatic induction led him to form conceptions of the nature of that action entirely different from those which had been previously held. Instead of looking upon induction as *action at a distance*, he regarded it as a phenomenon of the *medium* surrounding the electrified bodies, which he therefore called the *dielectric;* and he proved the correctness of his view by showing that the amount of induction varied with different media, and so discovered that property of dielectrics which was called by him their specific inductive capacity. It is interesting to observe that, although Faraday was in no degree a trained mathematician, his modes of thought were often eminently mathematical, such as was this notion of the dielectric medium as the seat of the energy of electrification. Where the earlier philosophers had seen nothing but distance between magnetic bodies or electrified conductors, Faraday pictured to himself an atmosphere of curving lines of force with such vividness that he sometimes speaks of them almost as if they were physical realities. This conception was always before him, and guided him to

many important discoveries, whilst in the hands of the mathematicians it became the starting-point of the modern mathematical theory of electricity.

Two more great discoveries remain to be mentioned. Searching for relations between the various forms of physical energy, Faraday found in 1845 that when a ray of polarised light passes through a transparent body between the poles of a magnet, the plane of polarisation is rotated to an amount depending on the strength of the magnetic field. This discovery was the first indication of a connection between magnetism and light; and although others have since been detected (notably a recent one by Dr. Kerr), the precise nature of the connection cannot be said to have been determined as yet.

Only a month later Faraday was ready to lay before the Royal Society another discovery of the first magnitude. When a bar of iron is freely suspended in a magnetic field it places itself along the lines of force in its neighbourhood. For instance, if it be between the poles of an electro-magnet it will take up a position with its axis in the direction of the line joining the poles. The same is true of cobalt and nickel, and so much was already known. Faraday found that *all* substances are affected by a magnet, but not all in the same way. Some behave like iron, and these he called *para-magnetic*, or simply *magnetic:* others he found behave in exactly the opposite way, setting themselves across instead of along the lines of force, and these he called *dia-magnetic*. That this difference is a real distinction of kind, as Faraday believed, and not merely of degree, as some have held (assuming the "magnetic permeability" of bodies to be in some cases greater and in some less than that of air), is proved by the discovery of Verdet that the rotation of a polarised ray in transparent paramagnetic media is opposite to that in diamagnetics.

Faraday had little direct connection with the development of telegraphy. About the time that he began to make his great discoveries in magneto-electricity he was receiving a large income by giving scientific advice in practical matters. Finding, however, that he could not serve the two masters—science and art, he renounced this, and was content to live on the modest sum which the Royal Institution gave him, supplemented in his later years by a pension from Government and a small salary as scientific adviser to the Trinity Board. Often, however, he gave advice without seeking pay. Dr. Gladstone tells us how, when the Atlantic Cable was mooted, Cyrus Field came to Faraday and begged him to make the necessary experiments to find out how fast a signal could be sent to America. He did so, and presently reported—

"It can be done, but you will not get an instantaneous message."

"How long will it take?" was the next inquiry.

"Oh, perhaps a second."

"Well, that's quick enough for me," was the conclusion of the American.

We have already mentioned Faraday's discovery of specific inductive capacity, the importance of which in this connection is well known to all practical electricians.

(*To be continued.*)

## THE IMPORTANCE OF A GENERAL SYSTEM OF SIMULTANEOUS OBSERVATIONS OF ATMOSPHERIC ELECTRICITY.

By W. E. AYRTON and JOHN PERRY,
Professors in the Imperial College of Engineering, Tokio, Japan.

THE great practical value of simultaneous meteorological observations is the assistance they afford us in enabling fairly accurate predictions of the weather to be made some hours in advance.

But all these observations are derived from instruments like the barometer, thermometer, &c., which are only affected by the air or other bodies in their immediate neighbourhood. A disturbance produced in the higher regions of the atmosphere cannot possibly affect a barometer or thermometer until this wave of disturbance has travelled down to the lower air strata, whereas electrical and magnetic instruments are instantaneously sensitive to disturbances produced at great distances: the pneumatic despatch and the electric telegraph may, in their difference of speeds, be taken as fairly analogous with the sluggish barometer and the ever-watchful electrometer.

Dr. Veeder has drawn attention forcibly to the fact that even surface winds, although they affect the weather, produce no changes in the barometer.

Now, since the value of all storm warnings increases with the time by which they precede the danger, the day may come when electrical and magnetic observations may not only aid, but actually supplant, barometric observations.

Mr. Cromwell Varley, the well-known electrician, having noticed that on several occasions earth currents were followed by a change of weather, communicated this fact to Admiral Fitzroy, who found such information of so much assistance to him in predicting the coming of storms, that he requested to have it regularly supplied. "On some occasions," says Mr. Varley, "Admiral Fitzroy could see the approach of a storm days before the barometer or thermometer indicated anything of the kind."

Our present knowledge of this subject may be summed up nearly in the words of Sir William Thomson in his address as President to the Society of Telegraph Engineers. Suppose for a moment that there were no electricity whatever in the air—that the air was absolutely devoid of all electric manifestation, and that a charge of electricity were given to the whole earth.

Well, now, if all space were non-conducting—and experiments on vacuum tubes seem rather to support the possibility of that being the correct view—if all space were non-conducting, our atmosphere being a non-conductor, and the rarer and rarer air above us being a non-conductor, and the so-called vacuous space, or the interplanetary space beyond that (which we cannot admit to be really vacuous), being a non-conductor also, then a charge could be given to the earth as a whole, if there were the other body to come and go away again, just as a charge could be given to a pith-ball electrified in the air of this room. Then, I say, all the phenomena brought to light by atmospheric electrometers, which we observe on a fine day, would be observed just as they are. The ordinary observations on atmospheric electricity are precisely the same as if the earth were electrified negatively, and

the air had no electricity in it whatever. In rainy weather, however, the potential of the atmosphere referred to that of the earth is sometimes positive and sometimes negative.

Observations made everywhere in the northern hemisphere tend to show that the potential is greater in summer than in winter, but the months of maxima and minima appear to differ at different places. Observations made at Kew and at Windsor in Nova Scotia show distinctly two maxima in the year, those at Brussels and Kreuznach only one. Both the Kew and Brussels observations show in addition two maxima daily, at 8 a.m. and 10 p.m. in July, at 10 a.m. and 7 p.m. in January, and at about 9 a.m. and 9 p.m. in the spring and autumn. Although, therefore, all the tests made at different parts of the earth's surface in fair weather (except some of doubtful meaning made at the Peak of Teneriffe in the early days of the study of this question) have shown the earth's surface to be negatively electrified, the amounts of the electricity existing at the same time at different places will be very different; and this difference manifests itself in a manner often extremely disagreeable to the telegraph engineer—in natural line currents.

The country in which these natural line currents have been most carefully studied is undoubtedly British India, since the uniform system of land line testing employed in the Government Telegraphs throughout that country causes the accurate measurement of these currents to be daily carried out. From the results of 10,000 such measurements it is seen that in India the direction of the current is far more constant than its magnitude, and on the whole there appears to be a marked preponderance of currents of positive electricity flowing from the east to the west—that is, with the sun; and such a current the laws of electro-magnetism tell us would be consistent with the earth's magnetism.

Observations made on the Atlantic Cables tend to show that when there are no unusual disturbances the earth currents at one end have two positive maxima and two negative maxima daily. Submarine cables, however, even when long, are far less disturbed by terrestrial currents than land lines, which may possibly be due to the sea having a far greater electric conductivity than the land.

Since the early days of telegraphy a large number of observations of natural currents have been made at the principal London Office in Telegraph Street, the results of which were communicated to the Astronomer-Royal. These tests seemed to show that natural currents in land lines were the continuations of the submarine currents which were arrested by the comparative non-conductivity of the land, for on Mr. Varley's endeavouring to find the neutral, or equipotential, line for the currents on the east coast of England, he found it to coincide approximately with the shore line.

During auroras these currents become extremely strong, sometimes as great as can be produced by the employment of a battery of 2,000 Daniell's cells, and occasionally even exceeding this. Of such currents the most extensive set of simultaneous observations that have been made was during the remarkable aurora of February 4, 1872; but as on that occasion these observations were not the result of any general system of measurement, but owed their origin to the fact that the currents became so strong as to interfere with the working of all the telegraph lines throughout the world, it cannot be expected that any large amount of information can be derived from the mass of records made on that day. One point, however, can be learnt from these observations, and that is this—first, the general direction of the positive currents was from east to west, that is, with the sun; secondly, along lines running north and south the currents were comparatively weak.

There seems to be no doubt now that earthquakes are preceded, or accompanied, by unusual strong natural currents in telegraph lines. As far as we are aware, attention was first drawn to this by one of the writers of this paper in a communication made to the Asiatic Society of Bengal, in June 1871, in connection with the Indian earthquake of February 16 of that year. The Indian earthquake again of December 15, 1872, was preceded with such strong earth currents during the evening of December 14 in the land lines from Valentia to London, that in order to send messages it was necessary to loop the lines by means of which the current in the one line was made to neutralise that in the other. The Egyptian earthquake of January 12, 1873, was preceded for some days by equally strong natural currents. This earthquake was also accompanied by an eruption of the volcano Shaptar Jokull in Iceland, which lasted from January 9 to January 12, and it is interesting to notice, as Mr. Graves, of the Atlantic Cable Co., has pointed out, that a direct line drawn from Cairo to Iceland crosses the telegraph wires from Valentia to London. Again, the Italian earthquake of March 17, 1875, was accompanied by great disturbances on the land lines of Italy.

From what has preceded it may be concluded with a fair amount of certainty that (1) atmosphere electricity, (2) auroras, (3) earthquakes, (4) magnetic distances, (5) natural currents in telegraphic lines, (6) sun spots, and (7) wind storms, are all linked together, and we feel that if this is shown, nothing more is needed to induce thinking people to interest themselves in the subject of this paper.

As regards the methods of measuring the atmospheric potential we have not much to add. Sir Wm. Thomson's quadrant electrometer, combined with his water-dropping collector, forms a very delicate measuring apparatus for observatories, and can easily be made self-recording; his portable electrometer and burning match may be used instead by travellers, or when neither very delicate observations nor automatic records can be taken. —*Abstract from Proceedings of the Asiatic Society of Japan.*

## ON RECENT IMPROVEMENTS IN THE HUGHES APPARATUS, AND A NEW METHOD OF TRANSLATION WITH THIS APPARATUS.*

HITHERTO special accessories have been required for Hughes apparatus when employed in automatic transmission from one line to another. There

* Abstract of a paper by M. von Hefner Alteneck (engineer of Messrs. Siemens and Halske's works in Berlin) in the *Journal Telegraphique*, to the editor of which we are indebted for use of the blocks used in illustration.

FIG. 1.

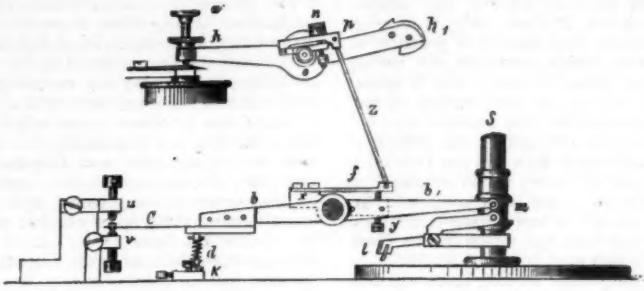



FIG. 2.

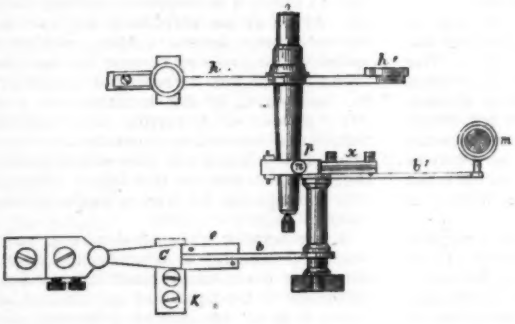



Fig 3

FIG. 4

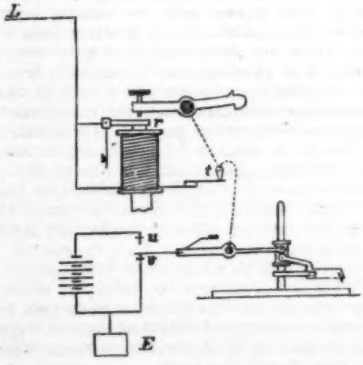
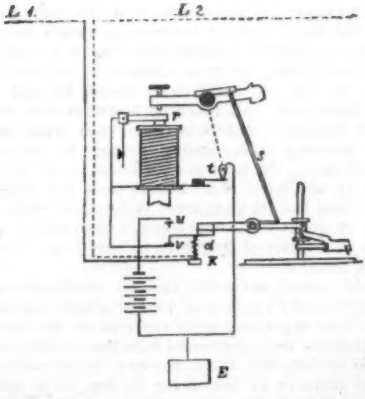



FIG 5



would be no use, and there would even be a disadvantage, in placing apparatus furnished with these accessories in stations which do not translate. Hence two systems: apparatus for translation, requiring employés specially trained, and simple apparatus for terminal stations only. Among various inconveniences thus arising in practice, a station provided with simple apparatus can never act as a translating station, though this is often desirable—*e.g.*, in changes of combination of the lines in cases of derangement, bad weather, &c.

The following method of meeting the difficulty requires no such difference between the transmitting and the simple apparatus, as is required in some other methods that have been proposed. It is combined with certain recent improvements in the Hughes apparatus (some of which are by Prof. Hughes himself), which may first be described.

In figs. 1 and 2, $h\ h_1$ is the locking lever capable of rotation about the axis *o*, and $b\ b_1$ Hughes' new contact lever. On the vertical axis S of the chariot there is a movable cylinder *m*, which rises when the chariot passes over a projecting pin; the lever arm $b_1$ moves up and down with it, but these motions may take place under other influences.

The contact spring C is fixed to the left arm of the lever $b\ b_1$, but an ivory plate *e* interrupts the electric contact between lever and spring. The electric current is brought to the spring C by a binding screw K and a spring *d*. The contact spring C carries on the two sides of its left extremity a platinum armature, and oscillates between the contact screw points *u* and *v*. The spring quits the lower (rest) contact, and comes against the upper (working) contact for an instant when the depression of a key moves the lever.

The right arm $b_1$ of the contact lever is coupled by means of the rod Z to the arm *p*, which is fixed on the axis of the locking lever $h\ h_1$, so that when the right arm of the contact lever descends, the locking lever descends also. This movement of $h\ h_1$, it is known, locks the axis during one revolution. One instant after, the excentric of the printing axis forcibly brings the locking lever into its position of rest, and the rod Z tends to restore the right arm of the contact lever and the cylinder *m*, and so press the movable part of the chariot down. But the usual form of the chariot would not allow of these different movements; for, at the moment that the locking lever is brought to its position of rest, the lip *l* of the chariot would be still above the raised pin. All those parts would thus be suddenly stopped; and considering the great force of the printing axis, injury would be inevitable. Accordingly, the lip *l* is shortened more than half (fig. 3), so that it is no longer over the projecting pin when the locking lever is brought to its position of rest. The consequent shortening of the time of contact of line with battery is not a serious disadvantage.

But further, even with this, the mechanism might be injuriously stopped, if two neighbouring keys or two keys separated from each other by less than three keys, were depressed simultaneously.

To obviate this, the lower end of the rod Z is not fixed directly to the lever $b_1$, but to a spring *f* (through an intermediate piece *x*) pressing strongly against the stopping screw *y*. The spring does not leave the screw in normal work, and the rod acts as if it worked directly under influence of the lever; but in the case supposed the spring yields. The screw Y also serves to equalise variations in length of the rod.

The electrical arrangements required by the mechanical locking differ essentially from those of the ordinary apparatus. To explain these figs. 4 and 5 are given, the former showing the connections in an apparatus (having the new contact lever and fixed rest and working contacts) *without* mechanical locking: fig. 5, those in the other case. In the latter, the line $L_1$ (supposing, for a moment, $L_2$ does not exist) does not communicate directly with the electro-magnet, but indirectly by the binding screw K, the spring *d*, and the lower contact screw *v*. The other electric communications are similar to those in fig. 4. A current, then, arriving from the line (excepting that it traverses the rest contact and the coils of the electro-magnet in inverse order) produces the same effects as in apparatus without mechanical locking—that is to say, it causes the armature of the electro-magnet to be liberated. This striking against the locking lever causes a slight rotation to the right, which has the effect, it is known, of locking the printing axis for an entire revolution, and producing the impression of a letter. Further, another direction opens to the arriving current, so that the superfluous part of this current finds a shorter path to the earth—viz., by the armature and the locking lever, instead of traversing the bobbins of the electro-magnet, and the contact *t* of the printing axis. The printing axis then commencing its rotation, and the contact at *t* being interrupted, the path through the bobbins is forthwith completely excluded from the circuit.

It is otherwise with the departing current produced by pressing a key. Immediately that, on this being done, the contact lever makes a small movement to the right, and so transfers its contact spring *v* to *u*, the current penetrates directly by the latter contact into the line $L_1$, without passing through the electro-magnet, as in the case without mechanical locking. The armature remains adherent to the electro-magnet, and the rotation to the right of the locking lever necessary to set in motion the printing axis is produced, as described above, by the rod Z. One instant after, the locking lever is brought, by the excentric of the printing axis, to its position of rest (touching with its arm the armature one instant motionless), and the contact lever is likewise brought back by the rod Z, so that the line is anew in communication with the rest-contact and the bobbins of the electro-magnet. These latter, however, cannot be affected by a charging current which will eventually flow from the line to earth, for the interruption at *t* excludes them from the passage of this current, which finds its escape to earth by the temporary contact of the locking lever with the armature at *r*.

The contact *r*, though it has lost its principal use, is retained, because it reduces the influence of the electric current on the receiver electro-magnet to the minimum necessary, and facilitates the discharge of the line by putting it, at the two stations, temporarily in contact with the earth.

Now all the change that has to be introduced to adapt the apparatus to the new method of translation consists in bringing the two levers into a greater

dependence on each other—in this sense, that not only the traction, but also the impulsion of the rod z, may affect the two levers. The arm *p* (fig. 1), which is extended to the right from the axis of the locking lever, and to which the rod is fixed, is composed, for this end, of two parts, connected by a hinge. The upper part of this hinge is prolonged to the right beyond the lower part, which is fixed to the locking lever, and carries on this prolongation, by means of an elbow-joint, the rod z. The screw *n* works in the lower part of the arm *p*, and passes freely through a hole in the upper part. By this screw the two parts of the arm can be united to form a *single* piece. In this case the rod z couples the two levers both in drawing and in pushing. But the rod has no longer anything but a drawing action if the screw is unscrewed a few threads, because in pushing it merely opens the hinge of the arm *p*.

At its lower end the screw *n* has a nut by which it can be fixed in the desired position.

The electric communications do not undergo any change for translation. The two lines merely ($L_1$ and $L_2$, fig. 5) are combined with the binding screw K. The three stations have the poles of the same name of their batteries joined up in the same direction. The translation may commence when the synchronic action of the three apparatus has been regulated in the known way, and the inferior position has been given to the screw *n*, of the intermediate station. The action is then as follows:

Let a current arrive from the line $L_1$, it bifurcates at the binding screw K, so that one part passes by the translation apparatus, and the other by the line $L_2$, by the apparatus to which it goes and the earth. But in the ordinary conditions, the resistance of this latter is so much greater than that of the apparatus, that there will only be a loss of a small quantity of the arriving current (if the resistance of the line $L_2$ were *nil*, this quantity would be half of the total current), and nearly the whole will pass by the apparatus of translation, where it will cause the releasing of the armature. This latter will strike against the locking lever, which turning will, by means of the rod, put the contact lever in motion as the depression of a key would do. The two lines are thus put in communication with the battery; but the current produced by the battery of the intermediate station, and returning on the line $L_1$, will be *nil* or very weak, because the station of transmission, which has the same pole of its battery in contact with the line, transmits an opposite current. Apart from this circumstance the bifurcation of the current at the binding screw K would not (according to a known rule) sensibly weaken the current passing into $L_2$, so long as the resistances of the lines are very great in relation to those of the batteries. This is an indispensable condition for batteries common to several lines, and the usage is now general. It has even much more importance in this multiple action of batteries than in the case which here occupies us. The translating apparatus then transmits a current, which arrives from the line $L_1$, immediately into the line $L_2$, as if the transmission emanated from it directly.

It remains to inquire whether the current impulse possibly going backwards from the translation apparatus may not do injury in the transmitting apparatus. If the latter is one of the old apparatus with unshortened lip, the current it sends out will last longer than the opposite current, which the translation apparatus tends to send back, so there will be no back-going current. And even if this obstacle did not exist, the back-flowing current could not be developed, for it would find the path through the bobbins of the electro-magnet barred by the interruption at *t* (figs. 4 and 5), and the action of the transmitting apparatus would not be deranged.

If, on the other hand, the transmitting apparatus has likewise a mechanical locking, the duration of contact of the batteries with the line $L_1$ will be of the same length; but from retardation of the effects of the current by the line and by the inertia of the electro-magnets, the translating apparatus will commence its action a little later than the transmitting apparatus, hence the back-going current will still subsist when that of the transmitting station will have disappeared. But in this case also this current finds the path through the electro-magnet of the transmitting apparatus interrupted at *t*, and, on the other hand, during a certain time a direct flow to earth at *r*; again, therefore, it cannot injure the regular action of the transmitting apparatus.

It is supposed that the back-going current does not last during an entire revolution of the printing axis, and experiments with artificial lines have shown this supposition to be correct.

Apparatus thus arranged for translation have been on trial at the central station of telegraphs of the German Empire since June 1875, and the results have been entirely satisfactory.

The new arrangement offers the following advantages, in addition to those already mentioned: the electro-magnets no longer work under the variable influence of two batteries, but under that of one only, that of the distant station. The force of the current then is uniform; this makes the regulation more easy, and gives more certainty to the reproduction of signals. The electric current is produced, besides, immediately, with all its force, for it has not to overcome in the first moment of its existence the resistances of the transmitting apparatus. Lastly, the joining up of the batteries of the two stations working together becomes independent. It is no longer necessary to combine the poles of contrary name with the line. As with the Morse, the same poles can be put in communication with the working contact. The general adoption of the system will render superfluous the present commutation, and will obviate the numerous inconveniences and losses of time connected with the joining up of the apparatus.

## LIGHTING STREET LAMPS BY ELECTRICITY.

MAYOR PRINCE, Alderman Slade, and other gentlemen of the Boston city government have been here inspecting the system of lighting the street lamps by electricity, which has been successfully introduced by the Electric Lighting and Telegraph Company. It should be stated at the outset that the system here in use is entirely different from those systems which have been tested in Boston and other cities without success. Hitherto attempts have been made to operate the stop-cock connected with the lamps and light, and extinguish the gas by

means of electricity. This method proved a failure, chiefly because of the faulty working of the stop-cock, which fact, of course, vitiated the whole system. The objections to this plan have all been obviated by the Electric Lighting Company. Instead of attempting to operate the stop-cock by the agency of electricity, compressed air is used, thus making the turning on of the gas and lighting it by electricity two entirely separate and distinct operations. By this process all the operations are conducted in clockwork order, and the failures in lighting the lamps in this city for six months have been less than one-fifth of one per cent., and the failures in extinguishing them have been less than one-fiftieth of one per cent., reckoning in both these estimates all defects arising from the clogging of the gas-burners, leakage of pipes, breakage of lanterns, and other mishaps, which are inevitable, even under the system of lighting by hand.

The process by which the lamps are lighted and extinguished is exceedingly simple. All the lamps are connected with a battery by an underground wire running through an air-tight tube, which is attached to an air-pump. This tube is half an inch in diameter, and is laid fifteen inches below the surface of the streets or side-walks. By a simple operation of the air-pump the stop-cocks connected with all the lamps are opened or closed, and by a single touch of the key connected with the electric battery the lamps, for a circuit of any length, be it one mile or one hundred, are lighted in an incredibly short space of time. If, from any cause, a lamp in the circuit fails of lighting or extinguishing, an indicator connected with the battery points out the number of the lamp so failing, and another touch of the key remedies the defect at once. These failures are of such exceedingly rare occurrence, however, as has already been shown, that but little or no importance is attached to this feature of the system. The cost of keeping the apparatus in running order and in good repair is scarcely appreciable, a matter of thirty or forty dollars being sufficient to keep up the works for a year. The services of one person amply suffice for conducting the entire work, and the only extra labour required is for keeping the lamps properly cleaned.

The company agreed to furnish the battery, the air-pump, laying the underground wires, and the entire apparatus necessary for conducting the work, at an expense of 50 dols. per lamp. The company guaranteed to effect an annual saving to the city of 15,000 dols. for the two thousand lamps in the city, or a *pro rata* saving on any smaller number of lamps that were given them. This necessitated an actual saving in the amount of gas used, and in the labour of lighting, of 7·50 dols. per lamp; but as the contract covered six months only, and called for the lighting of only two hundred and twenty of the two thousand lamps, the company was thus bound to show a saving of 825 dols. for the period covered by their contract, or forfeit all claim to reimbursement. This saving appears preposterously large at first thought, but when it is remembered that the services of lamp-lighters are dispensed with, and, what is still more important, that the lamps are all lighted in an instant when it is dark instead of half an hour or more before gas-light is required, as is invariably the case under the method of lighting by hand, the guarantee appears a reasonable one. That the experiment has been a successful one in every respect, and that the company has made good its boast, is shown by the fact that upon the expiration of the six months the city paid the company for its work, and an offer, based on precisely similar conditions, to light five hundred more lamps, is now before the city government. A saving of over 3·25 dols. per lamp was realised by the city during the six months.—*Providence Letter to Boston Post.*

## Notes.

THE Exeter town council have for a long time been negotiating with the gas company for the purchase of their works. One of the conditions of purchase was that the town council should secure to the original shareholders 10 per cent. in perpetuity. The town council have now, however, virtually decided, by a majority of 20 to 8, to break off the negotiations, mainly, as set forth by the mover of the resolution (Mr. Alderman Follet), on account of the success of the electric light and the probability of its superseding gas.

A NEW cable, 470 miles in length, is being laid between Marseilles and Bona, the steamship *Calabria* being employed for that purpose. On the completion of the work the *Calabria* returns to England, to ship a further length of cable 350 miles in length, to be laid between Bona and Malta.

MR. H. HÖNCHE has been appointed director of the Danish telegraphs in the place of M. Faber, deceased.

WE understand that Mr. W. H. Preece and Mr. H. C. Fischer, the commissioners sent out to inquire into the working of the American telegraph system, have just returned to England.

LIGHTING experiments with gramme machines are being tried daily at the Palais de l'Industrie, in Paris. The area of the building is 2½ acres; the elevation of roof, 95 feet. This immense space has been lighted *à giorno*, with two electric lustres, each composed of six electric lamps. The motive power required is fifty-horse power, and the results are very satisfactory, although it has not been stated whether they are superior to those of the Alliance system and Jablochkoff electric candle. The Paris-Lyons Railway is preparing an experiment for the illumination of the whole of the large Paris station. All these experiments are conducted with the intention of testing several electric systems, in order to obtain an immense lighting power for the 1878 International Exhibition.

## TRAFFIC RECEIPTS.

| 1877. | Anglo-American Co. | Brazilian Sub. Co. | Cuba Sub. Co. | Direct Spanish Co. | Direct U.S. Co. | Eastern Co. | Eastern Ex. Co. | Gt. Northern Co. | Indo-Euro. Co. | Mediterranean Ex. Co. | Submarine Co. | West Coast America Co. | Western and Brazilian Co. | West India Co. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN. ... | £ 37,780 | £ 11,469 | £ 2,311 | £ 983 | £ 13,530 | £ 42,580 | £ 24,147 | £ 12,663 | £ ... ... | £ ... ... | £ 9,668 | £ 2,533*b* | £ 10,100 | £ 4,058 |
| FEB. ... | 32,330 | 11,606 | 2,214 | 784 | 15,520 | 35,050 | 19,645 | 12,800 | ... ... | ... ... | 8,624 | 2,980*c* | 11,026 | 3,870 |
| MARCH ... | 18,880 | 11,258 | 3,025 | 913 | 8,110 | 35,491 | 22,886 | 16,115 | ... ... | ... ... | 9,915 | 3,128*d* | 11,643 | 5,854 |
| APRIL ... | 18,980 | 11,539 | 4,706 | 1,011 | 6,930 | 39,861 | 23,068 | 16,151 | ... ... | ... ... | 11,324 | 2,362*e* | 10,295 | *5,203 |
| MAY ... | 45,420 | 12,251 | *3,900 | 997 | 17,370 | 46,309 | 25,445 | 18,427 | ... ... | ... ... | 11,048 | 2,179*f* | 10,534 | *4,670 |
| JUNE ... | 40,040 | 9,742 | *3,200 | 887 | 15,260 | 45,477 | 24,126 | 19,663 | ... ... | ... ... | 9,960 | 4,025*g* / 2,225*h* | 10,522 | *3,671 |

* Estimated. *b*, four weeks ending 13th January. *c*, four weeks ending 13th February. *d*, four weeks ending 10th March. *e*, four weeks ending 7th April. *f*, four weeks ending 5th May. *g*, four weeks ending 2nd June. *h*, four weeks ending 30th June.

# City Notes.

Old Broad Street, July 13, 1877.

ALTHOUGH the shareholders of the Direct Company who have throughout opposed the policy of Mr. Pender and his confederates are in a hopeless minority, we most decidedly advise them to use all their power to wring the best terms that can be wrung from the liquidators of the company. It may, we know, be said that hostility can be carried too far. We rejoin that, in this instance, the clearly expressed wishes of a considerable body of responsible shareholders have been deliberately slighted; that, in point of fact, the only things they urged should be left undone have been done, and the things they desired should be done have been left undone. They are therefore justified in taking any step they can devise to protect their interests, if indeed there remain interests, at all hazards. Should the patience of Mr. Pender and his supporters be severely taxed, they will only be thankful for the precious opportunity afforded to them of manifesting their amiability in the hour of triumph.

We trust that a suggestion which has been made in a daily contemporary will be promptly followed. The dissenting minority of shareholders can lose nothing by forming themselves into a committee with the main object of insisting upon receiving the value of their shares in cash; they may gain something. It is true that, where a single individual may fail, a body of persons may succeed. Mr. Pender no doubt holds the shareholders who presume to question his sincerity and openly denounce his policy in supreme contempt. He is, to use a slang phrase, cock of the walk, and he is not likely to be disturbed by the crowing which may reach his ears from other parts of the ground. Still, the protesting minority cannot too soon withdraw from the company. It is now impossible that their counsel can have any effect upon the policy of the board. They did their best to stay its progress towards disaster; since disaster, sooner or later, has become inevitable, there is but one course open to them. They may thank Heaven when they are quit of their shares.

The wire-pullers have it pretty well their own way as it is. But perhaps when perfect concord reigns amongst the shareholders they may venture upon a movement which we have all along foreseen must come to pass at last. The decrease in the dividend on the Anglo-American Consolidated Stock, and also on the Preferred Stock, is an ominous sign. It may call for remark at the extraordinary general meeting of the shareholders of the Direct Company, which is being held while we are at press. But almost immediately the new company is formally constituted, and as soon as the troublesome shareholders who prefer their money to pieces of clean white paper have been disposed of, we venture to predict that an announcement will be made by the directors that on and after a certain date the charge per word for cable messages will be four shillings. Mr. Abbott, in his July circular, intimates that the critics who hold the opinion that the luxury of submarine cable communication with all parts of the world has been obtained at too great a cost are not entitled to be listened to. We coincide with Mr. Abbott in all that he can say respecting the benefactions we owe to the introduction of submarine telegraphy. We believe, moreover, that, although much, very much, has been accomplished, the great day of submarine cables is yet to come. Our engineers have done mighty things; but they will not be content to remain at a stand-still. They will go on, even unto perfection. But if submarine telegraphy is to extend its boundaries, it will assuredly need the assistance of the public. Engineering skill, astounding though it be, cannot work miracles; the question of vulgar dross must enter into every calculation. Mr. Pender and his fellow-directors may raise their tariff to four shillings. They will simply hasten their own overthrow. The public, as we have maintained again and again, will never submit to the three-shilling rate as a permanent thing; another shilling will call forth a storm which even Mr. Pender will be unable to contend against. We know, of course, the argument by which the advance will be justified. It was urged when the three-shilling rate was put into force, it has been constantly referred to as the unanswerable plea why the Direct shareholders should sacrifice their propery. We are without competitors, insists Mr. Pender; we may do just what we like; the public will come to us, for they have no one else to go to; the three-shilling rate does not yield the dividend we expected; another shilling will enrich us all, and render the shareholders of the amalgamated companies the happiest people alive. And for a time Mr. Pender's prognostications may be fulfilled. Everything may go on swimmingly, the shares of the concern may go up, Mr. Pender and his friends may realise, new blood may be infused into the enterprise, and the enterprise itself may virtually change hands—change

hands just before a new cable company cuts the ground from under its feet, and reduces its temporary profit to perpetual loss.

We observe that the directors of the Eastern Telegraph Company invite subscriptions at par for £200,000, in five per cent. debentures, the principal being repayable at the end of ten years. Undoubtedly, ten years is a very reasonable period, and if the amount is really required to complete the duplication of the company's route from Marseilles to India we do not think subscribers will run much risk. It is to be hoped that the "special facilities," which the directors of the Eastern company are said to be ready to grant as to rebates on the messages up to Aden, amounting, Mr. Abbott avers, "to a subsidy in favour of the Cape Extension line," will not impoverish the receipts of the company. It is all very well to talk about being reimbursed "from the increased traffic to be brought over their system by the business to and from the Cape;" but though it is certain the granting of "special facilities" will decrease the revenue, it is not so certain whether the traffic will increase in proportion. We make these remarks because of the strong optimism which seems to prevail in some quarters respecting the Eastern Telegraph Company. It may seem unkind to hint at such a thing, but the directors of the Eastern Company must take care the idea does not get wind that their movements are guided by a tender solicitude for the Telegraph Construction Company.

Mr. Abbott cannot conclude his circular without a reference to the West India and Panama Company. We recommended the shareholders of the Western and Brazilian to solicit Mr. Abbott to speak at their next meeting. He may perhaps be able to galvanise into life what has so long been supposed to be a corpse.

We have always believed in the ultimate prosperity of the Metropolitan and District railways. The dividend of the former has increased from 4 to 4½ per cent., and the reserve fund now stands at £20,000. In a few years the improvement will be more substantial. It is not surprising that the receipts of the Great Eastern have declined during the last six months. The Great Eastern Company is managed so badly that nothing that befell it would amaze us. Is it too much to expect that at the half-yearly meeting, which is fixed for the 31st instant, the proprietors will seriously consider the position and prospects of the company?

The decline in South-Eastern receipts is said to be due to a diversion of business, in consequence of the landslip between Folkestone and Dover. It must be consoling to the shareholders of the Chatham and Dover that their receipts have increased at a greater rate than those of any other company—the Midland and South-Western alone excepted. An increase in the Brighton dividend is looked for, but the South-Eastern have been compelled to make a reduction.

There appears to be quite a scare amongst the gas companies, in consequence of the glowing accounts daily received of the success of the electric light. We venture to say that this is a most unreasonable panic, and that the electric light is no more likely to supersede gas-lighting than the electric telegraph is likely to supersede the penny post.

The economical view of the question has by no means been threshed out. The simple fact that a saving of 50 per cent. can be effected in the working expenses by employing electricity in the place of gas is not the only point to be considered. The cost of replacing an existing and efficient plant by one which has yet to be designed, and which must be costly, must be taken into account, as it represents so much fresh capital necessary to carry out the new scheme of lighting.

As we have before stated, for special purposes the electric light may supersede gas, but for general lighting purposes we believe gas will hold its own.

# Proceedings of Societies.

## PHYSICAL SOCIETY—23rd JUNE, 1877.

Prof. G. C. FOSTER, President, in the chair.

PROF. W. GRYLLS ADAMS exhibited a very complete form of optical bench, which, in addition to being provided with all the improvements introduced by Prof. Clifton, carries an arm which can be set at any angle to it, and is provided with appliances for studying a beam of light or radiant heat when it deviates from the main axis of the instrument. At the base of a pillar, firmly clamped in any position, is fixed a horizontal graduated circle and a vernier, attached to a counterpoised arm which rotates round the axis of this pillar, rendering it possible to determine the angle made by the arm with the bench to one minute. At the upper extremity of the pillar is a steel pivot, to which various appendages may be clamped, and immediately below this is a second graduated circle by which to determine the angular position of whatever is supported by the pillar. Prof. Adams illustrated the use of the instrument by projecting on to a screen the interference bands obtained when a beam of light, after reflection from the two surfaces of a thick plate of glass, is again reflected from the two surfaces of a similar plate placed very nearly parallel to the first. A compensator, consisting of two plates of glass of equal thickness, is also added between the two thick plates, and an ingenious arrangement renders it possible to incline the glasses at any angle to one another, and to move them either independently or together. He also showed the effect produced in the positions of the bands when the rays from the two surfaces of the first plate traverse air of different densities before falling on the second.

Mr. F. D. BROWN exhibited an apparatus he has arranged in which to compare thermometers. From a brass hemispherical boiler rises a tube of the same metal, two inches in diameter, and about two feet long; the steam, after ascending through it descends a metallic jacket surrounding it, whence it passes into a U-shaped condenser, and from this it is returned to the boiler. The upper end of the condenser is in connection with a large air-tight vessel forming the base of the apparatus, and in which any required degree of exhaustion can be maintained by the use of Lothar Meyer's form of pump. The thermometers are placed in tubes, which pass within the wide brass tube, and by varying the nature of the liquid in the boiler and the pressure to which it is subjected, the boiling point can be retained constant at any required temperature.

DR. GUTHRIE and MR. AKROYD communicated a paper on electrical selection. When a metal or other body is rubbed against some non-conducting substance like caoutchouc, electricity is developed, and the track of the metal may be readily made evident by sprinkling on the caoutchouc a mixture of red-lead and sulphur. This sieving imparts negative electricity to the sulphur and positive to the red-lead, hence that particular ingredient of the mixture is drawn to the metal track, which possesses the opposite kind of electricity. Iron, for example, when rubbed against caoutchouc, generates negative electricity, and after sprinkling the powder, the iron track is revealed by the marked collection thereon of red-lead. A list of mixtures was given which may be used instead of the above, and it was shown that electrical selection may prove of use (1), in making an electrical diagnosis of the metals; (2), in certain experiments where the quadrant electrometer is objectionable; and (3), in teaching, where this instrument is often unavailable on account of its cost.

An Adjourned Special General Meeting of the Society was then held, after which the meetings were adjourned until November next.

# Correspondence.

[We do not hold ourselves responsible for any opinions expressed by our correspondents.—ED. TELEGRAPHIC JOURNAL.]

Paris, June 20, 1877.
69, Avenue Wagram,

*To the Editor of* THE TELEGRAPHIC JOURNAL.

SIR,—In requesting the favour of the insertion of a second letter in your well-known Journal, I would first ask your readers to excuse my again calling their attention to a subject which, in the eyes of competent men, has been sufficiently elucidated, but which interested obstinacy on the part of my opponents, together with a certain ingenuity of argument, has so mystified as to necessitate a second and more complete reply from me.

Before entering upon the technical details of this discussion, I wish to take exception to the Messrs. Wrays' insinuations as regards the character of my previous letter, and its "due manipulation on this side of the channel," and I cannot allow to pass unnoticed their scoffing allusion to me as "*Clamond & Co.*"

It is generally known that a Company was formed in England for the purpose of working my patents. The Messrs. Wrays' father was the Promoter, Chairman, and Managing Director of that Company, and *he* well knows that its title was not Clamond & Co. He knows, further, that I have now no interest in those patents.

One of my opponents, Mr. Cecil Wray, once delivered a lecture eulogising me and claiming for his father the honour of having introduced my batteries into England. He did not then, for very good reasons, designate them as "*ill-conceived piles.*"

If the Messrs. Wray contented themselves simply with vaunting the merits of their own handicraft, and in making known their pretended discoveries, without naming or attacking me, I should have allowed them to have continued their operations undisturbed, but I cannot permit those who have largely benefited by my labours to recommence similar proceedings with the object of attaining the same results by now levelling contumely and unjust criticism.

The Messrs. Wray say that they have "*worked out their object without reference to me or my patents.*" So far as I am personally concerned I am pleased with this declaration, for I should have been grieved if my name had been mentioned in the conception of such absurd thermo-electric bars as they have produced; but as regards the statement that those gentlemen have had nothing to do with my patents, I would point out that what I have above stated clearly establishes that either directly, or through paternal counsels, they have had the opportunity of becoming acquainted with my processes of manufacture.

It is for this reason I am surprised that they maintained that the tin-iron plates are oxidised by being heated with the moulds, as they might be sufficiently well informed not to ignore the fact that the moulds are heated separately, and that the tin-iron plates are only introduced gradually as the metal is poured in. The reply to the other questions raised will be found in the course of this letter.

My object is to avoid any legal controversy, which should certainly not have place here. I shall therefore merely point out that in order to prove that the Messrs. Wray have "*copied me*" on certain points, I need not discuss whether such or such a patent has lapsed, or no longer belongs to me. Suffice it to prove my priority by documentary evidence, and the proof of the "*copy*" follows as a necessity.

A patent is a title establishing the commercial property of the inventor. He may sell it, or allow it to lapse, but in point of fact he can always say: I was the first to do this or that, and you have copied it.

Having to examine the principal claims of the Messrs. Wrays' pile, I can only find that they are but the reproduction of those I had already made.

1st. Insulating discs supported by projecting blocks (Borrowed and copied from the patent of Mure and Clamond, *vide* the patent No. 3060 of 1868.)

2nd. The terra-cotta multiple burner, gas being admitted inside (copied and borrowed from Clamond's patent No. ).

3rd. The earthenware heating chamber (arrangement employed in Clamond's pile).

The two first facts are not contradicted by the Messrs. Wray, but they claim to be the inventors of the earthenware heating chamber.

As an illustration of the evidence I can produce on this subject, I here give a copy of a certificate from Monsieur Rousselon, Director of the works of the well-known firm of Goupil and Company:—

(TRANSLATION.)

"Asnières, June 19, 1877.

"I, the undersigned, certify that in the course of the year 1875, in the month of *June* or *July*, upon the request made to him by me, and upon my suggestion, Monsieur Clamond caused to be placed inside his thermo-electric piles at work in our factory, a fire-clay cylinder, so fixed that each bar touched its exterior surface, and that thanks to this method Monsieur Clamond's thermo-electric piles have since that time rendered constant and regular service.

(Signed) "H. ROUSSELON."

This important testimony also explains the reason why I did not patent the earthenware heating chamber, as I do not belong to that category of people who do not hesitate to appropriate to themselves the ideas of others by patenting them, even when they have good evidence that they do not belong to them.

Having thus established beyond the question of a doubt that the three principal claims of the Messrs. Wray, which constitute the skeleton and heating system of their pile, are merely copied from what I had already done, I will now proceed to demonstrate that the said skeleton is filled with bars made against all the "*known and admitted laws*," and, having done so, I consider that my statement in a previous letter that they had made but a "*bad copy*" of my pile is completely justified.

May I now request your readers to refer to the diagram as given in that letter (*vide* TELEGRAPHIC JOURNAL No. 104, of 1st June).

If the conductor C D is prolonged to $A_0$, so as to unite the two extreme conductors $A_0$ and $A_2$, and at the same time connect the two conductors $a_0$ and $a_2$ to a galvanometer, the conductor C D will be a shunt, and the current which will pass through the galvanometer will be but a portion of that which should pass if the shunt C D did not exist, and its intensity will be calculated by the well-known formula for shunted galvanometers. If the wire or conductor C D be replaced inside the bar by an elongated tongue sufficiently extended to reach from B to A, and having the same resistance as C D, we shall see the same current as before, and we shall have realised these bars, destined to become famous in point of ridicule, with which "*the curious little pile*" has been constructed, and of which the outer and inner positions are cut out of one piece of metal, so that a strip runs through the whole length of the bar.

The Messrs. Wray, by way of defence, say that if my

allegation that the elongated tongue or shunt inside the bar is assimilable to the outside shunt C D were true no current would be obtained with the above-mentioned bars, whereas they obtain a very considerable one.

Now, in accordance with those *known and admitted laws*, the discovery of which has made Ohm so justly celebrated, I reply that in both cases a current is produced which is, however, but a portion of what would be obtained without the shunts, and the force of which depends upon the reciprocal resistances of the exterior circuit and the shunts, whether they are placed inside the bar or outside and parallel to the bar. The only difference would be caused by the slight increase in resistance of the interior shunt by the heat.

As a practical demonstration, these gentlemen not appearing to be strong in theory, I have made two bars with the dovetail connections, one of which has both positives cut out of one piece of metal, while the other has them distinct and separate, without the elongated tongue, both bars being alike in dimensions and run from the same metal. When connected successively with the same galvanometer, the first bar, as a matter of course, gives a weaker current than the second, which is not shunted; but by shunting this second bar *outside*, with a plate identical to the one which shunts the first bar *inside*, the strength of current of the second is reduced to that of the first.

Now, if the two poles are not shunted, and one of them has an elongated tongue, the latter shunts that portion of the bar which envelopes it, and the loss of current decreases in proportion to the shortness of the tongue.

To make my argument complete, I should add that if a bar be made much too long (of an exaggerated length) in proportion to its section, so that the shunted portion of the bar is at a considerable distance from the source of heat (and consequently at about the same temperature and potential), the effect of the tongue will no longer be to shunt a sensible portion of the current, but to diminish the resistance of the inactive portion of the bar.

This discussion reminds me of an incident in connection with a young inventor with whom I was acquainted. In order to reduce the resistance of Smee's pile he connected the silver and zinc plates by means of a silver wire. To those who endeavoured to convince him of his error he replied, with much assurance, that inasmuch as the silver wire was in the liquid it did not act as a shunt placed outside, and he adduced as an argument that a shunt outside would prevent the formation of any current whatever, whereas by his arrangement he obtained a very strong one. "The electro-magnetic force is diminished," said he, "but largely compensated for by the diminution of the resistance, and finally I obtain better working effect." Some of his friends smiled and left him to his hapless ignorance, while others recommended him to go to school again.

The Messrs. Wray, however, publish a letter from Messrs. Clark, Ford, & Co., in which these gentlemen give the results of measurements they have made upon two series of 18 bars each, one series being provided with long positives and the other with short positives.

I recognise the great competency of these gentlemen, and admit the accuracy of their figures, and I do so with all the more pleasure that the Messrs. Wray will be unable to alter those figures to-morrow as they do their own, according to the requirements of the discussion.

I will now proceed to make calculations which establish the consequences of the results of Messrs. Clark, Ford, & Co.'s figures:—

$$\left.\begin{aligned}\text{Long positives } I &= \frac{1{\cdot}133}{0{\cdot}392} = 2{\cdot}89\\ \text{Short positives } I &= \frac{1{\cdot}226}{0{\cdot}438} = 2{\cdot}79\end{aligned}\right\}\ \text{Ohm's laws.}$$

In the case the most favourable to the long positives, that is, when the exterior resistance may be disregarded, the work or energy is represented as follows:—

$$\left.\begin{aligned}&\text{Long positives—}\\ &\text{Work} = I \times E = \frac{E^2}{R} = \frac{1{\cdot}133^2}{0{\cdot}392} = 3{\cdot}274\\ &\text{Short positives—}\\ &\text{Work} = I \times E = \frac{1{\cdot}226^2}{0{\cdot}392} = 3{\cdot}420\end{aligned}\right\}\ \text{Zoule's law.}$$

The two first results demonstrate that while the long positives, owing to their smaller resistance, only increase the intensity by less than four per cent., they decrease the electro-magnetic force by more than eight per cent.

The second results indicate that the work force is sensibly diminished by the elongated tongues.

As regards the solidity which the tongue is said to give, that is a very questionable point. There is no proof whatever in support of the statement; there is no experience to guide one, and no theory to justify the assertion. This letter is already so long that I dare not discuss that point now. I will, therefore, merely remark that, even assuming for argument sake that the long positives, as described by the Messrs. Wray, do strengthen the bar, they can surely only strengthen those portions of the bar which are shunted, and which, as I have said above, are either useless or very inactive.

Messrs. Clark, Ford, & Co.'s figures seem also to show that the Messrs. Wrays' bars are too long, and that a series of *short positive bars*, shorter by 25 per cent., would have shown still more conclusively the bad effect of the tongue.

I believe that I have now demonstrated theoretically and experimentally that the Messrs. Wrays' bars are made against all *known and admitted laws*, and consequently that their apparatus is but a *bad copy*.

These gentlemen speak of a *new alloy*, and in reference thereto I cannot express an opinion, being ignorant of its composition. I would only say that alloys giving a higher electro-magnetic force than zinc-antimony have long been known and used. Cadmium-antimony alloy, for example, would make bars ten of which would be equal to one volt. The only obstacle to the commercial use of this alloy is the high price of cadmium.

In conclusion, I would assure the Messrs. Wray that I have never claimed to be the only person who has devoted his attention to thermo-electricity. I am well aware that the question has occupied the minds of many learned men. I have given many years to its study myself, and no one would be less surprised than I, if, to-morrow, new and unforeseen discoveries gave to thermo-electric currents novel and largely extended applications.

I promise the Messrs. Wray that if ever they succeed in making any real improvement in this field of science, I will acknowledge its value and merit with the same impartiality and frankness with which I have to-day refuted their errors.

I am, Sir, your obedient Servant,

C. CLAMOND.

## To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which THE TELEGRAPHIC JOURNAL is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the EDITOR; business communications to the MANAGER, 10, Paternoster Row, E.C.